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A PORTABLE INFILTROMETER AND UNIT SYSTEM FOR DETERMINING RELATIVE INFILTRATION RATES

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To ascertain the rate of water intake of a soil profile under different conditions of land use, various types of run-off plots, lysimeters, rain-simulators, tube apparatus, and the more recently developed portable infiltrometer have been used. The principal disadvantages in using most of the above equipment and methods for determining the relative infiltration rates of the numerous soil and vegetative cover conditions typical of any large watershed embracing several thousand square miles, are the difficulties of simulating natural rainfall and of making sufficient tests within reasonable cost and time limits to obtain reliable results. The infiltrometer and unit system herein described are especially adapted for the rapid determination of relative infiltration rates of areas comprising numerous soil series, cover conditions and land uses, and it is believed the apparatus has considerable possibilities in view of the current need for infiltration data on Flood Control Surveys. The general appearance of this unit in operation is given in Figure 1 and the specifications and details of construction are indicated in Figure 2.

The test quadrat of each infiltrometer is 18 inches wide and 20 inches long and has a surface area of 2-1/2 square feet. The plot boundaries are delineated by No. 10 gage galvanized steel forced into the ground approximately six inches. A small trough with a 1/2-inch outlet is welded to the front border and catches the surface run-off from the plot. Water caught in this run-off trough drains through a 1/2-inch copper tube to a collection basin where it is measured by means of a graduate in cubic centimeters.

"Rainfall" is applied artificially by means of one to three nozzles[1] located about two feet above the edge of the plot. Water enters the nozzles under a pressure of 15 pounds per square inch which is provided by a centrifugal pump and 3/4 - 1 hp. gasoline motor. A uniform rainfall intensity is maintained by regulating a constant pressure on each supply line by a special system of valves and pressure gages called "manifold" and a pressure regulator[2] at the nozzle assembly. Irregularities in the pressure supply commonly developed from slight fluctuations in motor speed are overcome by installing

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1/ Nozzle developed by Hydraulic Laboratory, Soil Conservation Service, Division of Research, Washington, D. C.

2/ Watts Pressure Regulator No. 26AC. Size 3/8". Stock Setting 15 lbs. Watts Regulator Company, Lawrence, Mass.

a small surge tank in the supply line near the pump outlet. The spray is forced upward over the plot and falls five to six feet in the form of fairly large drops uniformly distributed. The size of the area wetted by one infiltrometer during a test is four by four feet, or 16 square feet, whereas run-off measurements are made only for the centrally located plot having a surface area of 2-1/2 square feet. The rainfall intensity varies according to the number of nozzles in operation since each nozzle contributes approximately two inches of water per hour.

The exact amount of water falling on the test quadrat is ascertained by means of a pan one inch deep which fits over the plot borders and has a surface area equal to that of the plot. The water falling on this calibration pan drains into the collection basins and is measured in the same manner as surface run-off.

A collapsible pipe frame and canvas cover are erected around each plot to eliminate the effects of wind movement on the spray. The dimensions of the windbreak when fully assembled are four by four feet and seven feet high.

One to four infiltrometers can be operated efficiently in a unit, thereby increasing the number of replications possible in the same period of time required to make a single test. Sufficient hose should be provided so that the infiltrometers are well distributed over the sampling site on which the testing unit is located. The most economical number of infiltrometers to use in a unit depends on the number of tests desired on each sample site. Two to three unit set-ups can be made in an eight-hour day, depending on the distance the equipment is moved between set-ups. One complete unit of four infiltrometers and power unit can be transported by a one-half ton pick-up. The water supply should be transported on a separate truck

The operating procedure is extremely simple. After the exact location of the plot has been ascertained, the plot borders are forced into the soil to a depth of approximately six inches so that the run-off trough is flush with the surface of the ground. The plots borders are installed so that the run-off trough is always at the lowest end of the plot. The windbreak frame is then assembled. The nozzle arrangement is installed at one side of the plot and held in place by two iron stakes and the adjustment collars. The area between the plot borders and windbreak is covered with canvas to prevent excessive wetting when checking the "rainfall" intensity. A shallow hole is dug about 10 inches in front of the windbreak for the run-off collection basins and the drain pipe from the run-off trough to the collection basin is set in place. The fitting of the canvas cover over the windbreak frame completes the installation.

The calibration pan is placed over the plot to check the "rainfall" intensity prior to the test. Run-off from this pan is caught in the collection basins and measured in a liter graduate at one- or two-minute intervals. When the intensity is ascertained, the calibration pan and canvas are removed from inside the windbreak and the time is recorded or stop watch started. Run-off from the plot is measured at one-, two- or five-minute intervals, depending on the amount and rate of increase. Run-off in cubic centimeters per minute is converted to inches per hour by multiplying by the factor .01018 or roughly one cubic centimeter per minute equals .01 inch per hour.

The run-off from the plot gradually increases to a maximum, which when reached, remains fairly constant. If it remains practically constant for a period of 30 minutes, the test is usually completed. The calibration pan is again placed over the plot to recheck the rainfall intensity and determine any change in rate which might have occurred during the test. Since the amount of water retained on a plot 18 by 20 inches by depression storage and surface retention is very small, the difference between rate of run-off and rate of "rainfall" applied can be used as the infiltration rate at any particular time of the test for all practical purposes. However, if desired, the amount of water retained on the plot as depression storage and surface retention can be ascertained by a hydrograph analysis as developed by Sharp and Holtan 3/.

The total cost of all equipment required for one infiltrometer unit consisting of four infiltrometers and capable of making 12 runs per day, as in Figure 1, is approximately $350.00. One man is required to assemble and operate each infiltrometer used in the unit. One man is required to assemble the pressure system, service the power unit and regulate the water pressure for all infiltrometers at the centrally located manifold during the runs.

3/ Sharp, A. L., and H. M. Holtan.
1940. A Graphical Method of Analysis of Sprinkled Plot Hydrographs.
Paper presented at Hydrology Section, Amer. Geo. Union., Washington, D. C.

Your attention is called to the factor ".01018" in the second-last line, page 2, of Technical Note No. 11, recently sent you by this Station. This figure should be ".01017."

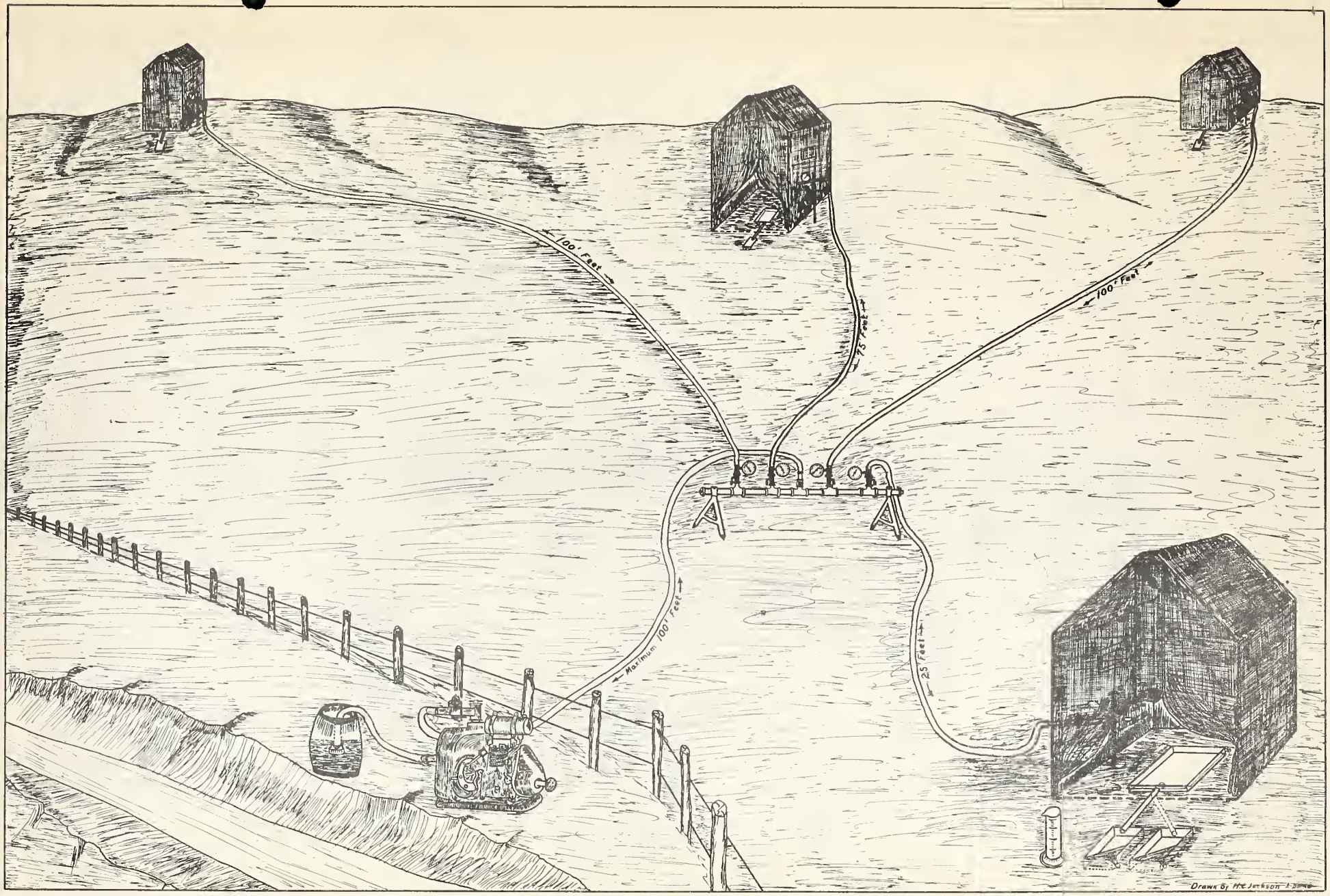

FIGURE I. A UNIT OF FOUR INFILTROMETERS IN OPERATION

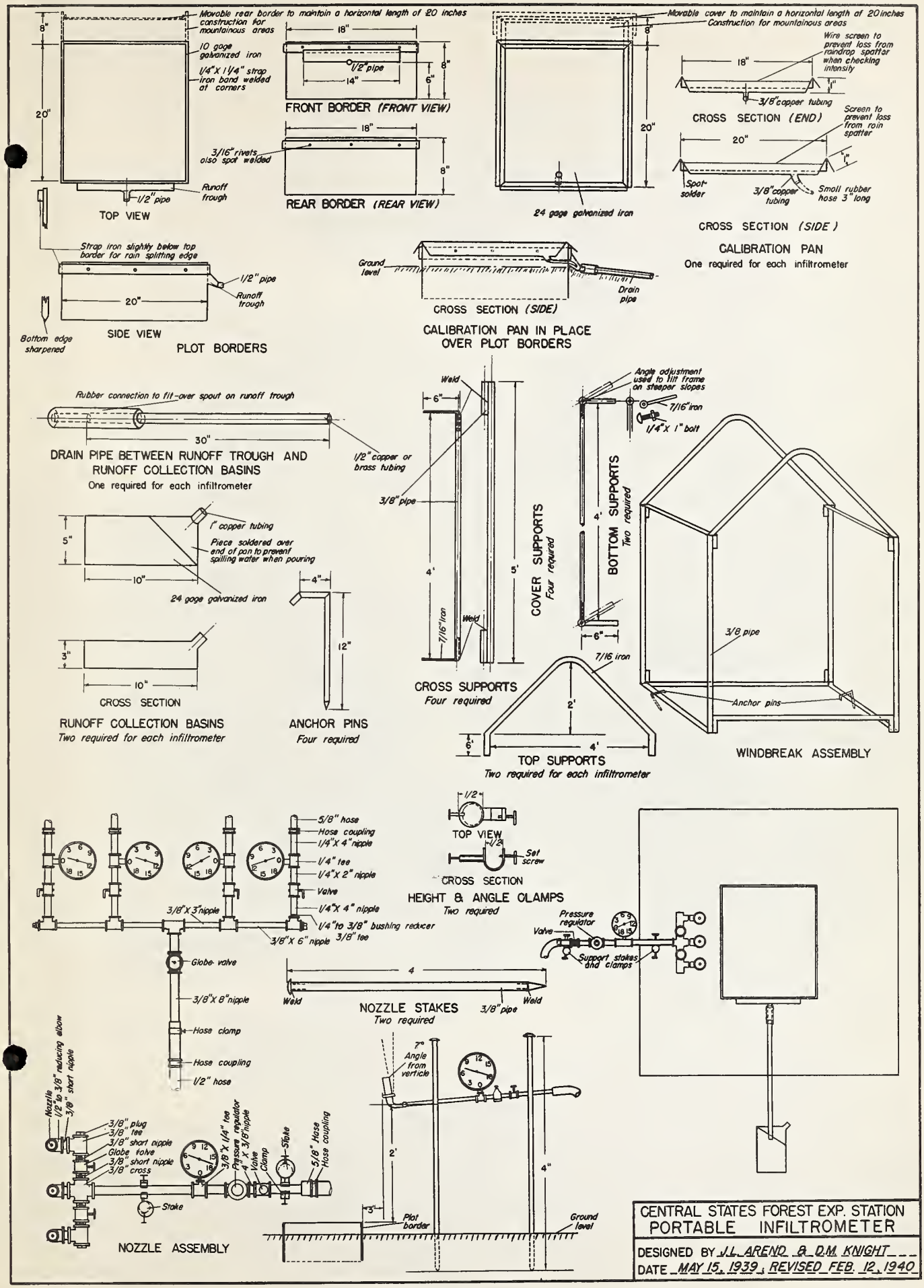
Movable rear border to maintain a horizontal length of 20 inches
construction for mountainous areas
10 gage galvanized iron
1/4" x 1 1/4" strap iron band welded at corners
8"
20"
1/2" pipe
Runoff trough
TOP VIEW
18"
1/2" pipe
14"
6"
8"
FRONT BORDER (FRONT VIEW)
3/16" rivets also spot welded
REAR BORDER (REAR VIEW)
Strap iron slightly below top border for rain splitting edge
20"
SIDE VIEW
Bottom edge sharpened
PLOT BORDERS
Movable cover to maintain a horizontal length of 20 inches
Construction for mountainous areas
24 gage galvanized iron
Wire screen to prevent loss from raindrop spatter when checking intensity
3/8" copper tubing
CROSS SECTION (END)
Screen to prevent loss from rain spatter
Spot solder
Small rubber hose 3" long
CROSS SECTION (SIDE)
CALIBRATION PAN
One required for each infiltrometer
Ground level
Drain pipe
CROSS SECTION (SIDE)
CALIBRATION PAN IN PLACE OVER PLOT BORDERS
Rubber connection to fit over spout on runoff trough
30"
DRAIN PIPE BETWEEN RUNOFF TROUGH AND RUNOFF COLLECTION BASINS
One required for each infiltrometer
1/2" copper or brass tubing
1" copper tubing
Piece soldered over end of pan to prevent spilling water when pouring
5"
10"
24 gage galvanized iron
3"
10"
CROSS SECTION
RUNOFF COLLECTION BASINS
Two required for each infiltrometer
4"
12"
ANCHOR PINS
Four required
Weld
6"
3/8" pipe
4'
5'
7/16" iron
Weld
COVER SUPPORTS
Four required
CROSS SUPPORTS
Four required
Angle adjustment used to tilt frame on steeper slopes
7/16" iron
1/4" x 1" bolt
4'
BOTTOM SUPPORTS
Two required
6"
7/16 iron
2'
6"
4'
TOP SUPPORTS
Two required for each infiltrometer
3/8 pipe
Anchor pins
WINDBREAK ASSEMBLY
5/8" hose
Hose coupling
1/4" x 4" nipple
1/4" tee
1/4" x 2" nipple
Valve
1/4" x 4" nipple
1/4" to 3/8" bushing reducer
3/8" tee
3/8" x 3" nipple
3/8" x 6" nipple
Globe valve
3/8" x 8" nipple
Hose clamp
Hose coupling
1/2" hose
1/2
TOP VIEW
1/2
Set screw
CROSS SECTION
HEIGHT & ANGLE CLAMPS
Two required
Pressure regulator
Valve
Support stakes and clamps
4
Weld
3/8" pipe
Weld
NOZZLE STAKES
Two required
Nozzle
1/2" to 3/8" reducing elbow
3/8" short nipple
3/8" plug
3/8" tee
3/8" short nipple
Globe valve
3/8" short nipple
3/8" cross
Stake
3/8" x 1/4" tee
Pressure regulator
4" x 3/8" nipple
Valve
Clamp
Stake
5/8" Hose
Hose coupling
NOZZLE ASSEMBLY
7° Angle from vertical
2'
4"
3"
Plot border
Ground level
CENTRAL STATES FOREST EXP. STATION
PORTABLE INFILTROMETER
DESIGNED BY J.L. AREND & D.M. KNIGHT
DATE MAY 15, 1939, REVISED FEB. 12, 1940

FIGURE 2